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A BRIEFING TO ADDRESS "LIVEWARE INTEGRATION NEEDS"

Earl A. Alluisi

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Office of the Assistant Secretary of Defense for
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The briefing text and slides contained in this document were developed as part of a *human system integration* (HSI) effort to integrate all *human system components* (HSC) into the weapon system acquisition process--an effort that, in turn, is a relatively small part of the much broader joint Department of Defense (DOD)-industry initiative in *computer-assisted acquisition and logistic support/concurrent engineering* (CALS/CE). The briefing was presented on December 11, 1992, in Strasbourg, France, as part of a workshop on "Liveware Integration Needs" sponsored by the North Atlantic Treaty Organization (NATO). Five topical areas are reviewed: (a) system concepts, (b) processes employed to integrate HSC (people or "Liveware") into the design of systems, (c) goals of the joint DoD-industry initiative to develop and implement CALS/CE in the acquisition process for future weapon systems, (d) the role of CALS and CALS-HSC as HSI-enabling technologies that will provide the practical means to integrate human system components into the acquisition process, and (e) the likely future of these "Liveware," HSI, and CALS-HSC efforts.

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Many persons, too numerous to list, have contributed to development of the concepts upon which this briefing on "Liveware Integration Needs" has been based. However, the author wishes to acknowledge his appreciation for the helpful comments and valuable contributions made to the improvement of the final draft by S. Deitchman, M. Fineberg, J. Fletcher, J. Orlansky, and M. Pearce. Most, but not all of their advice has been incorporated into this final version, so the author reserves for himself the sole responsibility for all errors and faults that remain. Finally, the author wishes to express his gratitude to Michael L. Pearce (Workshop Chairman), for having presented the briefing at the workshop in Strasbourg in lieu of the author, who was not able to attend.

CONTENTS

ABBREVIATIONS FOR REFERENCED DOCUMENTS

AC/243-Panel 8	—	formal identification of DRG.8
CAD	—	computer-aided design
CALS	—	computer-assisted acquisition and logistic support
CALS/CE	—	computer-assisted acquisition and logistic support/concurrent engineering
CALS-HSC	—	computer-assisted acquisition and logistic support—human system components
CAM	—	computer-aided manufacturing
CE	—	concurrent engineering
DED	—	data element dictionary
DIS	—	distributed interactive simulation
DoD	—	Department of Defense
DoD-HFE-TG	—	Department of Defense Human Factors Engineering Technical Group
DRG	—	Defense Research Group (a NATO-sponsored activity)
DRG.8	—	Defense Research Group Panel 8 (on *Defense Applications of Human and Bio-Medical Sciences*)
EG	—	Exploratory Group
EG.G	—	Exploratory Group G (on *Liveware Integration in Weapon System Acquisition*)
IDA	—	Institute for Defense Analyses
HSC	—	human system components
HSI	—	human system integration
NASA	—	National Aeronautics and Space Administration
NATO	—	North Atlantic Treaty Organization
R&D	—	research and development
RDBMS	—	relational data base management system
RSG	—	Research Study Group (an ad-hoc DRG-sponsored task group)
RSG.21	—	Research Study Group 21 (on *Liveware Integration in Weapon System Acquisition*)
TOR	—	Terms of Reference
USA	—	United States of America

INTRODUCTION

A principal goal of the joint Department of Defense (DoD)-industry initiative in *computer-assisted acquisition and logistic support/concurrent engineering* (CALS/CE) is to create computer-based digital technologies to replace the paper-intensive techniques used currently in acquisition, logistic, and engineering processes and practices. The briefing text and slides contained herein are meant to contribute, at least in small measure, to the achievement of that goal. They were developed through a *human system integration* (HSI) effort that aims to integrate all *human system components* (HSC) into the weapon system acquisition process as part of the CALS/CE initiative.

NATO-Sponsored Workshop on "Liveware Integration Needs"

The briefing was presented on December 11, 1992, in Strasbourg, France, at a Workshop on "Liveware Integration Needs," sponsored by Research Study Group 21, *Liveware Integration in Weapon System Acquisition* (RSG.21), Defense Research Group Panel 8, *Defense Applications of Human and Bio-Medical Sciences* (AC/243-Panel 8; also, DRG.8), the North Atlantic Treaty Organization (NATO). The briefing was presented by the Chairman of RSG.21, Mr. Michael L. Pearce of the Office of the Assistant Secretary of Defense for Force Management and Personnel (Human Systems Integration), in lieu of the author, Dr. Earl A. Alluisi, who was not able to attend.

Terms of Reference (TOR) for RSG.21

The Terms of Reference (TOR) for RSG.21 defines the term, *liveware*, as consisting of the manpower, personnel, training, safety, human factors engineering, and health hazard prevention factors that influence the performances of a weapon system. It observes further that these factors constitute major and increasingly expensive components of any weapon system, and that they should be addressed fully at the outset of the system-design process.

For example, the quality and quantity of personnel required to field a system need to be identified early in the process. Issues related to system total costs and to the availability of trained manpower will have to be identified, articulated, and resolved as decisions are made in the process of designing, developing, acquiring, and operating the system.

RSG.21's TOR stated further that although there are technologies currently available to accomplish such integration, they have only recently begun to be systematically surveyed, and they have yet to be collected into efficient formats. Furthermore, the methodology to conduct *liveware* analyses, and to accommodate them to other system-design criteria, is still incomplete.

Thus, DRG.8, on the recommendation of its Exploratory Group G (EG.G), charged RSG.21 to address several important areas that require research and development (R&D), specifying primarily the following three:

(a) The identification, definition, and description of techniques, tools, databases, and data collection systems that enhance the early consideration and integration of *liveware* factors to improve the operational performance and cost-effectiveness of new or modified weapon systems.

(b) The documentation of such existing *liveware*-integration technologies into formats suitable for practical use in accommodating profiles, report requirements, and trade-off analyses at the appropriate milestone-review points in the acquisition process.

(c) The identification and documentation of *liveware*-integration technology gaps, to include a broad outline and recommended prioritization of R&D efforts designed to close those gaps.

Summary of RSG.21 Activities

The group held its first two meetings during 1990, (a) at the *Forschungsinstitute für Anthropotechnik*, Wachtberg-Werthoven, Germany, on May 15-17, and (b) at the NASA-Ames Research Center, San Jose, California, USA, on October 23-26. The meetings were devoted largely to obtaining a better understanding and appreciation of the various member nation's acquisition processes. In addition, the group agreed on the scope of their effort (i.e., on the size and complexity of the tasks to be accomplished), and adopted a tentative outline for their final report and a handbook to accompany it.

The third and fourth meetings of RSG.21 were held the next year, 1991, (a) the third at the *Établissement Technique D'Angers*, Angers, France, on April 22-26, and (b) the fourth at the *Industrieneanlagen-Betriebsgesellschaft mbH*, Ottobrunn, Germany, on October 8-11. During these two meetings, the group reached general consensus on the definitions of *liveware* terminology from which a database could be built, reviewed a prototype database, developed a tentative agenda for a workshop proposed to be held the next year, developed an interim report, and discussed further the structure of the final report and handbook.

RSG.21 held two meetings and a workshop during 1992, (a) its fifth meeting at the Defence and Civil Institute of Environmental Medicine (DCIEM), Toronto, Canada, on March 9-13, (b) the sixth at the Defense Training and Performance Data Center (TPDC), Orlando, Florida, USA, on July 6-10, and (c) the workshop at the *Cercle des Officiers*, Strasbourg, France, on December 8-11. The meetings were given over primarily to reviewing the progress in construction of the *liveware* database, including the resolution of data-entry issues, further detailing the scope and focus of the final report, and planning for the workshop, including its agenda, format, and other administrative details, in addition to the selection of presenters and papers. The workshop on "Liveware Integration Needs" was considered crucial to the successful completion of RSG.21's work and its meeting the requirements of its TOR.

A Briefing to Address "Liveware Integration Needs"

The briefing recorded here was scheduled to be (and was) presented immediately after the call to order at the morning plenary session on the final day of the workshop (December 11, 1992). In planning the briefing, the author saw it as an opportunity to present a summarizing statement that would "wrap-up" the workshop by reviewing the background for RSG.21's task and the direction in which the *liveware*-integration efforts should, in his view, be moving.

Thus, in five major sections, the briefing reviews five topical areas, as follows:

- System concepts, including (a) views regarding major system components, (b) older notions of how systems should be designed, and (c) newer ideas of system "wares"—i.e., the things that are to be produced to build total systems, with emphasis on the "Liveware" or "Human System Components (HSC)" of systems.
- Processes employed to integrate HSC (people or "Liveware") into the design of systems—from the "Personnel Subsystem (PSS)" approach of the 1950's, to the "Human System Integration (HSI)" technique of the 1990's.
- Goals and objectives of the joint Department of Defense (DoD)-industry initiative to develop and implement *computer-assisted acquisition and logistic support* (CALS) and *concurrent engineering* (CE) in the acquisition process for future weapon systems.
- The role of CALS, and specifically of CALS-HSC (its *human system components* element), as HSI-enabling technologies that will provide practical means to integrate human system components into the acquisition process.
- The likely future of these "Liveware," HSI, and CALS-HSC efforts.

TEXT TO ACCOMPANY SLIDES

Text to accompany a briefing prepared for presentation at the RSG.21 Workshop

On "Liveware Integration Needs," 8-11 December 1992, Strasbourg, France

Entitled: "Liveware, Human Systems Integration (HSI), and

Computer-Aided Acquisition and Logistic Support—

Human System Components (CALS-HSC)"

Prepared by: Dr. Earl A. Alluisi, Institute for Defense Analyses, Alexandria, Virginia, USA

Presented by: Mr. Michael L. Pearce, Office of the Assistant Secretary for Manpower and Personnel (Human Systems Integration), Washington, DC, USA

SLIDE #1—(Title Slide)

Fellow members of RSG.21 and distinguished guests. I am pleased to be able to present the paper prepared by Dr. Earl Alluisi. Many of you may recall that he was quite instrumental in having RSG.21 established.

He writes: "I am honored by the invitation to address you today at this RSG.21 Workshop on 'Liveware Integration Needs.' I had hoped to be present, but circumstances would not have it so. As you may know, I was diagnosed with lung cancer about a year ago (on 12 December 1991), and have undergone chemotherapy for 10 months and radiation therapy for 2 months. I appreciate very much the good wishes many of you have sent, and I am happy to report that I continue both to feel well and to have reasonably good chances of being among the lucky 5 to 8% with whom the disease goes into longer-term remission."

SLIDE #2—Overview

We shall cover five main topics, plus a few subtopics.

First, we shall review some system concepts, including the major components of a system, and the older concepts of how systems should be designed. We shall also cover the system "wares"—that is, the things that are to be produced if we are to design and build total systems. The emphasis is on system *liveware* or "Human System Components (HSC)."

Next, we shall review how we have gone about the tasks of integrating HSC (people or *liveware*) into the design of systems—from the "Personnel Subsystem (PSS)" approach of the 1950's to the "Human System Integration (HSI)" approach of the 1990's.

Then we shall review the goals and objectives of the US Department of Defense and Industry initiative to develop and implement computer-aided acquisition and logistic support (CALS) and concurrent engineering (CE) capabilities in the design and development of future weapon systems.

The role of CALS as the technology that will enable HSI—the integration of the human system components (HSC) into the acquisition process—will then be discussed, and the CALS-HSC thrust will be reviewed.

Finally, we shall end the presentation with a look to the future of these *liveware*, HSI, and CALS-HSC efforts.

SLIDE #3—System Concepts

A "system" consists of things, people, and ideas,

- — the interfaces among them,
- — all integrated into a single whole,
- — and existing within an environment or a context.

This is symbolized in the graphic presentation where

- — the three slices of the pie represent the things, the people, and the ideas,
- — the borders between the slices represent their interfaces,
- — the circumference represents their integration,
- — and the background represents the environment or context.

SLIDE #4—System Design—Old Concepts

The "old" concepts regarding system design are depicted graphically and with text on this slide.

- "Things" are to be designed and built—they "sell!"
- The "people" will adapt to the fielded system,
- The "ideas" are the domain of the military,
- The "interfaces" will be handled as necessary, and
- "Integration" will be accomplished later by the prime contractor.

Briefly, in the past we have built hardware—not systems!

SLIDE #5—System Wares—New Concepts

Some of the newer "system-ware" concepts can be symbolized as —

- "Hardware and software" (the system's "things"),
- "Liveware," (the system's "people"), and ,
- "Mindware" (the system's "ideas" or operational concepts).

"Software" is the one system "ware" that is becoming increasingly important as a part not only of the "things" component, but also of all the other system components—the people, ideas, interfaces, and integration, as well as system adjustments for differing environments or contexts.

The "software" component, not only of the weapon system being designed, but also of the acquisition process used in system design and development itself, is recognized as being quite important. It is the subject of the CALS initiative. We shall speak about this later.

SLIDE #6—Human System Components

By "Liveware," "People," or the "Human System Components," we mean all those items that impact on the proper operation and maintenance of a system, and upon which the system has its own impacts.

These are the components that must be integrated through the process into the design and development of the system. Formally, these items are usually grouped under four rubrics as follows:

- Manpower and Personnel,

— Education and Training,

— Simulation and Training Devices, and

— Safety and Human Factors Engineering.

SLIDE #7—Integrating HSC in System Design

The US Air Force early recognized the need for, or potential benefits of, the integration of "personnel" aspects within a system's approach to weapon-system acquisition.

In fact, from the very earliest days of its existence as a separate Service, the US Air Force mandated the use of the systems approach to weapon-system development.

Then, during the 1950's, they established the concept of a Personnel Subsystem (PSS) and ordered that the PSS be considered in every weapon system developed for the Air Force.

The mandate was intended to force weapon-system developers to consider in their designs the impact of the "people" aspects that might otherwise be ignored in favor of exclusive concentration on the "hardware" aspects of the weapon system.

As implemented, the PSS approach involved the manpower, personnel, training, and human factors engineering parts of what we now call the "human system components" or "HSC."

SLIDE #8—Mid-Century Engineering Design/Drafting Bay

Implementation of the Air Force mandate to include the PSS in all weapon-system design was accomplished by industry, primarily within its engineering domains.

In the industrial settings of those days, design was usually accomplished by many engineers working at many drawing boards in large bays within a design facility.

The author had the good fortune of working as a human factors engineer in such a facility during the late 1950's. He, like the other human factors engineers in the *Personnel Subsystem Department* to which they were assigned, was attached to one such large bay.

He was responsible for the human factors engineering of every piece of equipment (or hardware) that was being designed in that bay. Thus, he was expected to know, or learn, not only about all things that were being designed, but also about the concepts of their operations.

He was then to bring the information back to the manpower and personnel specialists, and the training specialists, in the *Personnel Subsystem Department.* They, in turn, would do

their parts to integrate the manpower, personnel, and training aspects of the human system components into the design.

Specifically, they would prepare and keep current their documentation—the Qualitative and Quantitative Personnel Requirements Information (QQPRI) and the Training Plan (which in later design states would include technical manuals and training materials).

RETURN NOW TO SLIDE #7

Implementation of the Personnel Subsystem met with mixed or limited success.

There were too few well-trained human factors engineers, their contributions (and mechanisms for making their contributions) were not well worked out nor well understood.

The enabling technologies were weak at best, and

the *Personnel Subsystem Departments* were too often judged "not cost-effective," most especially when funds were needed to solve unexpected hardware-design problems.

The US Air Force dropped the Personnel Subsystem requirements during the 1960's.

SLIDE #9—Human System Integration (HSI)—US Approaches

Now, during the 1990's, there is renewed interest in, and emphasis on, "Human System Integration (HSI)," a modern rebirth of the PSS or "Liveware" issues.

The US approach to HSI is intended to solve three well-recognized problems—acquisition costs, life-cycle costs, and fielded-equipment inefficiencies. Specifically:

(1) **Acquisition costs.**—The costs of weapon system design, prototype development, and test have increased tremendously.

Much of the increase is attributed to the additional costs of development changes, hardware modifications, or system redesigns found necessary by tests of system prototypes with troops in the field.

Many of the cost escalations could have been avoided had the system's "liveware" been better integrated during acquisition, especially during the earlier design stages.

(2) **The life-cycle costs.**—The costs of operating, maintaining, and supporting a system during its operational life have proven to be prohibitively (often *unnecessarily*) high in money, manpower, or both.

Liveware integration is aimed at making the life-cycle costs an element of prime importance in the charge to the weapon system developer.

The project manager is now to attend to the life-cycle costs, not merely the costs of initial acquisition of the system. He is now required to include the results on life-cycle costs of trade-off analyses of alternative design concepts.

(3) **Fielded-equipment inefficiencies.**—Failures of new systems to live up to expectations when tested in the field have been identified as a third major problem.

Some new weapon systems have failed to deliver fielded performances at the level of their design capabilities. That is, when operated by troops in the field, these new weapon systems have failed to reach the levels of accuracy and lethality of which the hardware is capable. Also, bench tests of even of some existing systems vary widely from the performances of the same systems in the field with actual Service troops.

In many cases, analysis and redesign have confirmed that such inefficiencies could have been avoided had the initial design incorporated some of the established principles of human performance—in short, had the "liveware" been better integrated into the system during the acquisition process.

To solve these problems, the US DoD has taken *three broad approaches*. The *first* is by mandate from the top level; namely, the publication in February 1991 of the new

— DoD Directive 5000.1, "Defense Acquisition,"

— DoD Instruction 5000.2, "Defense Acquisition Management Policies and Procedures," and

— DoD Manual 5000.2-M, "DoD Manual for Defense Acquisition Management Documentation and Reports."

The *second* approach is through comparable guidance issued by each US Military Department to provide for the related regulations or instructions issued by each of the individual US Services in complying with (adopting and adapting to) the DoD Directive, Instruction, and Manual.

Such Service-level planning and guidance is necessary because each US Service independently acquires, operates, and maintains its own weapon systems.

The *third* approach is through the specific implementation programs to integrate liveware considerations into each Service's process of acquiring weapon systems, and by renewed emphasis and stimulation of the DoD-Industry initiative on Computer-Aided Acquisition and Logistic Support and Concurrent Engineering (CALS/CE).

The Service programs are known by their acronyms: MANPRINT in the US Army, HARDMAN in the Navy, and IMPACTS in the USAF.

We shall not address these programs, nor their differences, here. Rather, we shall concentrate on the advances in technology that have produced the CALS/CE initiative—an initiative that we view as the technological breakthrough that will permit HSI or "Liveware-Integration" to succeed now, during the 1990's, where the "Personnel Subsystem" approach was deemed to have failed during the 1950's and 1960's.

SLIDE #10—An Early CAD/CAM Work Station

The major enabling technology is, of course, the digital computer and its peripheral equipment

— especially when configured as an engineering computer-aided design/computer-aided manufacturing (CAD/CAM) work station—

— increasingly networked with other work stations to provide "hands-on" interactive design contributions from engineers and specialists with different areas of expertise, all with the single goal of optimizing the design.

The most promising of recent technological innovations for those working in the HSC areas is, perhaps, the use of virtual-world technology to provide for man-in-the-loop simulations and synthetic environments with which "virtual prototypes" of new weapons and weapon systems can be tested and evaluated.

If all goes as is currently planned, we will have seen our final "fly-off" of physical prototypes, and in the future the "fly-offs" will be on the computer with models and simulations of alternatives. The decision will then be reached, and only a single version of the physical prototype will be built.

This same technology is the basis for increased emphasis on integration of the *mindware* (the operational-concept component) in weapon system design. Analyses of new system concepts are beginning to include the results of man-in-the-loop interactive simulations of the proposed system compared with similar simulations of current systems. The systems are "tested," using their associated concepts and doctrine or tactical uses, with actual troops operating in battle engagement simulations that can now be created with networks of simulators and wargames. Such analyses are just starting; the technology is still in its infancy, but progress is being made very rapidly, especially with expansion of the basic capabilities in *distributed interactive simulation* (DIS).

SLIDE #11—CALS Integrated Environment

Computer-Aided Acquisition and Logistic Support (CALS) is a DoD and industry initiative to transition the paper-intensive acquisition and logistic processes to a highly automated and integrated digital-flow mode of operation for weapon system acquisition in the 1990's and beyond.

The concept of CALS development is *to evolve* the desired digital data and databases from the paper-intensive processes that have been typically employed. The evolution is to create an integrated environment that includes —

- engineering (analysis, design, test and evaluation),
- manufacturing (tooling, material, and process), and
- logistic support (maintenance, modification, provisioning, reprocurement, spares and support equipment ordering, supportability, analysis, technical manuals, and training).

Note that *training* was included from the beginning of the CALS initiative as an element of logistic support. We shall pick up on this point later.

SLIDE #12—Computer-Aided Acquisition and Logistic Support (CALS)

The CALS *goals* are to increase operational readiness and industrial competitiveness through use of integrated, digital-flow data, databases, and networks that increase the efficiency of the design process, improve the product, and enhance industrial competitiveness.

The goals will be reached when all the information for system design, manufacture, and support are included in the databases available through electronic networks to all authorized DoD and industry users, fully integrated for use in the design phases and throughout the system's life cycle.

The CALS *objectives* are

- *To reduce time,* especially both acquisition and "out-of-service" time, through more efficient and better integration of engineering, manufacturing, and logistic support.
- *To reduce costs,* especially by (a) eliminating labor-intensive development of duplicate data, (b) replacing paper by accurate, timely, and cost-effective digital technical information, and (c) providing for data sharing by multiple users with interoperable applications.

— *To improve quality*, by integration of the "ilities" into the computer-aided design tools, thus reducing errors in weapon system design, manufacturing, and logistic support.

The CALS *process* is to evolve from the paper-intensive processes of today,

— through an intermediate phase of electronic-flow information from flat-file-like databases,

— finally, to fully integrated relational-file-like digital databases.

SLIDE #13—CALS and the Human System Components (HSC)

As indicated earlier, training had been recognized as an element of logistic support from the very beginning of the CALS initiative.

Therefore, there had been organized a Training Work Group as part of the joint DoD-Industry CALS Steering Committee.

However, it was recognized that acquisition and logistic support impact on, and are impacted by, not only training, but also all Human System Components (HSC); namely,

— Manpower and Personnel,

— Education and Training,

— Simulation and Training Devices, and

— Safety and Human Factors Engineering.

So, during 1991, it was decided that all HSC, not merely training, was to be integrated into the CALS effort, and CALS-Training evolved into the CALS-HSC Work Group.

SLIDE #14—Maximize CALS through CALS-HSC Integration

The CALS-HSC goal is to maximize the CALS objectives through the integration into CALS of all HSC.

Among the analytic models or tools that have already been developed and used to resolve HSC issues are the following:

— *Manpower*:

Logistics Composite Model (LCOM)

Authorization Projection Model (APM)

Manpower Standards Development System (MSDS)

— *Training*:

Instructional Systems Development (ISD)

Training System for Maintenance (TRANSFORM)

Training Analysis Support Computer System (TASCS)

— *Design and Safety*:

Crew Chief (CC)

Computerized Biomechanical Man-Model (COMBIMAN)

— *Costing*:

Life Cycle Cost Models (LCC-2; LCC-2A; LCCH)

Logistics Support Cost Model (LSC)

— *Logistic Support*:

Logistic Support Analysis (LSA)

Logistic Support Analysis Record (LSAR)

— *Integrated*:

Instructional Systems Development/Logistic Support Analysis Record—Decision Support System (ISD/LSAR-DSS)

SLIDE #15—CALS-HSC—1992 Progress—HSI

Progress made during 1992 in CALS-HSC integration (or HSI, as we have called it), include:

— 30 demonstrations of software tools during the HSI Software Fair held in conjunction with a meeting of the DoD Technical Group on Human Factors on 4 November 1992 in Huntsville, Alabama. (The Technical Group consists primarily of bench-level human factors engineering scientists and research supervisors, rather than administrators or managers.)

— The completion and publication of a CALS-HSC Data Element Dictionary.

— The preparation of a document based on this presentation to address "Liveware Integration Needs" or from a broader view, the relations among liveware, HSI, and CALS-HSC.

We shall discuss each of these very briefly during the time remaining.

SLIDE #16—DoD-HFE-TG Meeting

As just stated, the demonstrations of HSI software tools took place on the DoD Human Factors Engineering Technical Group meeting on 4 November 1992 in Huntsville, Alabama.

- The HSI software fair was sponsored by the Air Force Materiel Command's Center for Supportability and Technology Insertion (CSTI/PIAT).
- Government-owned microcomputer-based software tools addressing any HSI elements were invited; ~30 came.
- The demonstrations were limited to software that is available free-of-charge to all US Government agencies.
- The demonstrations were made by US Government representatives and contractors.

SLIDE #17—Data Element Dictionary (DED)—Process

The Data Element Dictionary represents the middle phase in a process that is intended to advance, in stages, from —

- A starting point where relevant HSC data elements exist in many different documents, to —
- An intermediate phase where there is a single comprehensive CALS-HSC Data Element Dictionary that can be used and which can form the basis for —
- proceeding to a final goal-phase an integrated, digital, electronic, relational database management system.

SLIDE #18—IDA Document D-1183 (October 1992)

The CALS-HSC Data Element Dictionary (or "DED") that has now been distributed,

- incorporates over 430 data elements,
- that were developed from analyses of official standards and contractual data item descriptions (DIDs),
- complies with all relevant DoD Directives, Instructions, Handbooks, and Standards,
- is interoperable with the data elements of the Logistic Support Analysis (LSA), and
- has been coordinated with Industry and DoD CALS and HSC communities.

Still—it is to be viewed as a "living" document that is to be amended, corrected, and expanded as experience is gained in its use.

SLIDE #19—Briefing Documentation (IDA D-1087, March 1993)

This document (IDA Document D-1087, March 1993) has been prepared to record the briefing and to reiterate the issues identified and comments made. Its underlying agenda is to address the needs for future development of the Human Systems Integration (HSI) efforts. It has sought —

- to include the historical roots of the CALS-HSC integration (HSI) efforts, as well as some more-recent history of HSI-related activities and efforts,
- to relate both the historical roots and recent HSI activities to the historical aspects of HSI information requirements, dictionaries, standards, and the DoD-Industry CALS/CE initiative,
- and, thereby, to indicate the likely direction of future liveware, HSI, and CALS-HSC efforts, and their consistency with the CALS/CE goals and objectives.

SLIDE #20—Computer-Generated Maintainability Test

Many different forms of HSI software tools have been demonstrated. They range from

- decision support system aids that help a training system designer navigate through a series of questions to produce the documentation for the ISD (i.e., *Instructional Systems Development*), using the data of the LSAR (i.e., *Logistic Support Analysis Record*) prepared by the hardware designer for the system under development [as demonstrated with the ISD-LSAR DSS development tool], to —
- dynamic computer models of anthropometrically correct manikins performing maintenance tasks on computer models of equipment being designed, but not yet being built [as in the CREW CHIEF model].

The photograph is an example of a computer-generated maintainability test—it demonstrates that the tool sweep shows the arm (in blue on the video) will impact the structure as currently designed. Such demonstrations provide information to the engineer to permit him to decide upon and make necessary changes while the system is still in the computer-aided design (CAD) format. This is much more efficient and much less costly than the alternative of making the changes after physical prototypes have been built and tested.

SLIDE #21—Computer-Generated Dynamic Manikin Model

A second example is shown in this slide. It is a photograph of a computer model of a dynamic anthropometrically correct manikin performing a "remove and replace" maintenance task on a computer model of equipment being designed, but not yet being built.

These two examples illustrate the real advances that are being made. They have moved the tests for functions and characteristics such as maintainability and accessibility from the physical mock-up or prototype of the system being developed back to an earlier design phase where "virtual" hardware is tested with "virtual" liveware—both being represented with dynamic digital computer models at the engineering work station.

This is progress. And even though a great deal has been accomplished, an even greater deal has yet to be achieved before we reach our goals of having the liveware, or human system components, fully integrated in the design process.

SLIDE #22—CALS-HSC Integration—Benefits

Once the needs are met, the CALS, the CALS-HSC, and the HSI goals will be achieved with the predicted benefits of —

- *Reduced Time*, because the design would have been "right the first time, the data were there when needed, and the data would have been converted already into terms and measures meaningful to the engineering-design functions.
- *Reduced Cost*, through the use of efficient integrated, relational-type digital databases, resulting in fewer retrofits or engineering change proposals (ECPs), and data produced only once—no duplication of efforts.
- *Improved Quality*, resulting from consistency of data (not only in time, but also in place), all HSC factors being integrated and considered during design, with the outcome being fewer design errors.

SLIDE #23—(Closing Slide)

The integration of the Human System Components

- into the Computer-Aided Acquisition and Logistic Support effort (CALS-HSC)
- is truly the key
- Human Systems Integration (HSI) or "Liveware" Integration
- will be achieved through CALS-HSC.

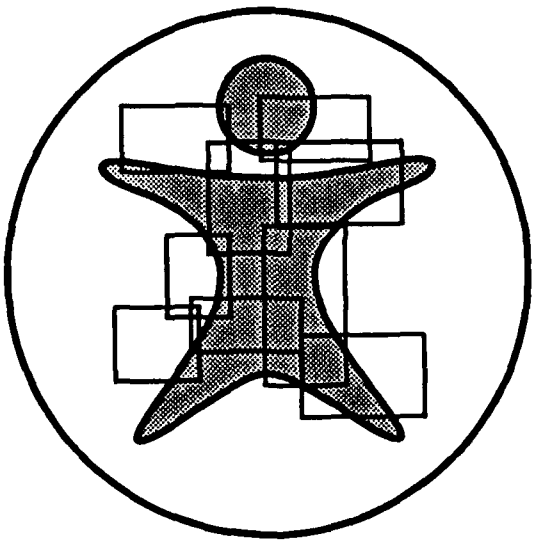
Thank you for your attention. Are there any questions?

APPENDIX:

SLIDES TO ACCOMPANY A BRIEFING ON

"LIVEWARE INTEGRATION NEEDS"

Liveware, Human Systems Integration (HSI), and Computer-Aided Acquisition and Logistic Support — Human System Components (CALS-HSC)



Earl A. Alluisi, and Michael L. Pearce
Institute for Defense Analyses, and OASD(FM&P)(R&R)(HSI)

RSG.21 Workshop: *Liveware Integration Needs*
8-11 December 1992, Strasbourg, France

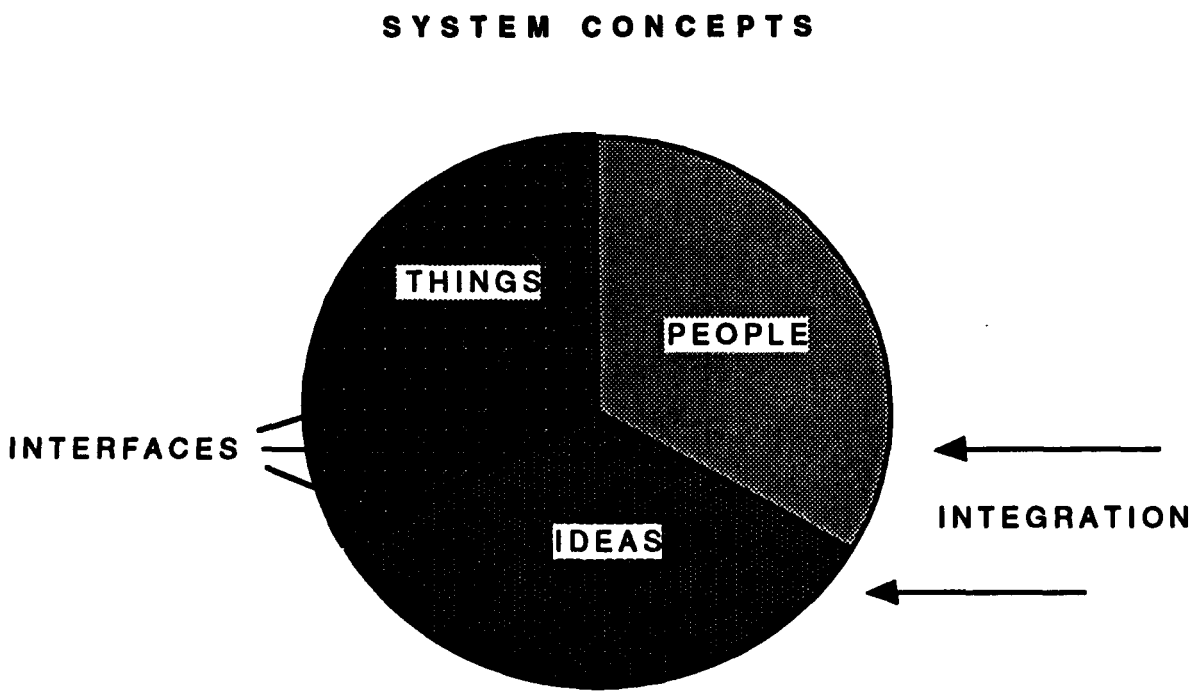
Liveware, HSI, and CALS-HSC

Overview

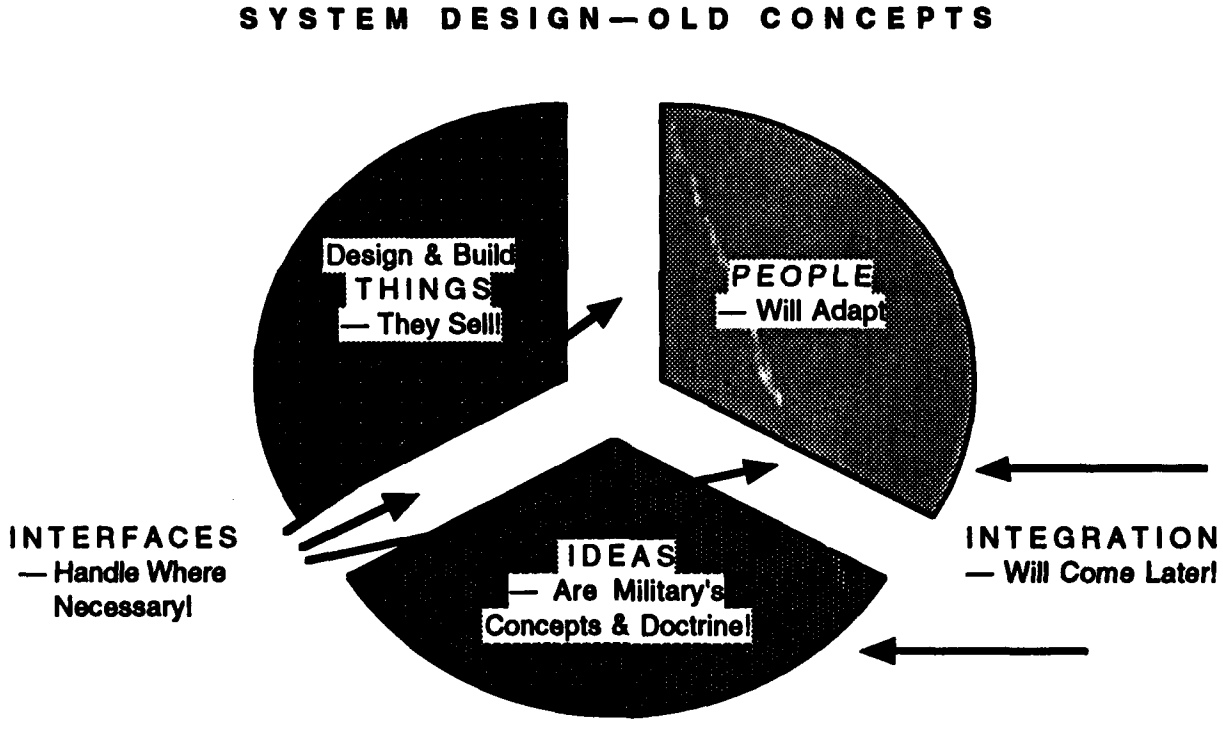
- ◊ System — Concepts and "Wares"
  - — System Components — Old Design Concepts
  - — "Liveware" — Human System Components (HSC)
- ◊ Integrating HSC (People or "Liveware") in System Design
  - — The Personnel Subsystem (PSS — 1950's)
  - — Human Systems Integration (HSI — 1990's)
- ◊ Computer-aided Acquisition and Logistic Support (CALS)
- ◊ CALS-HSC
- ◊ The Future: Liveware, HSI, and CALS-HSC

RSG.21

System — Concepts and "Wares"



System — Concepts and "Wares"



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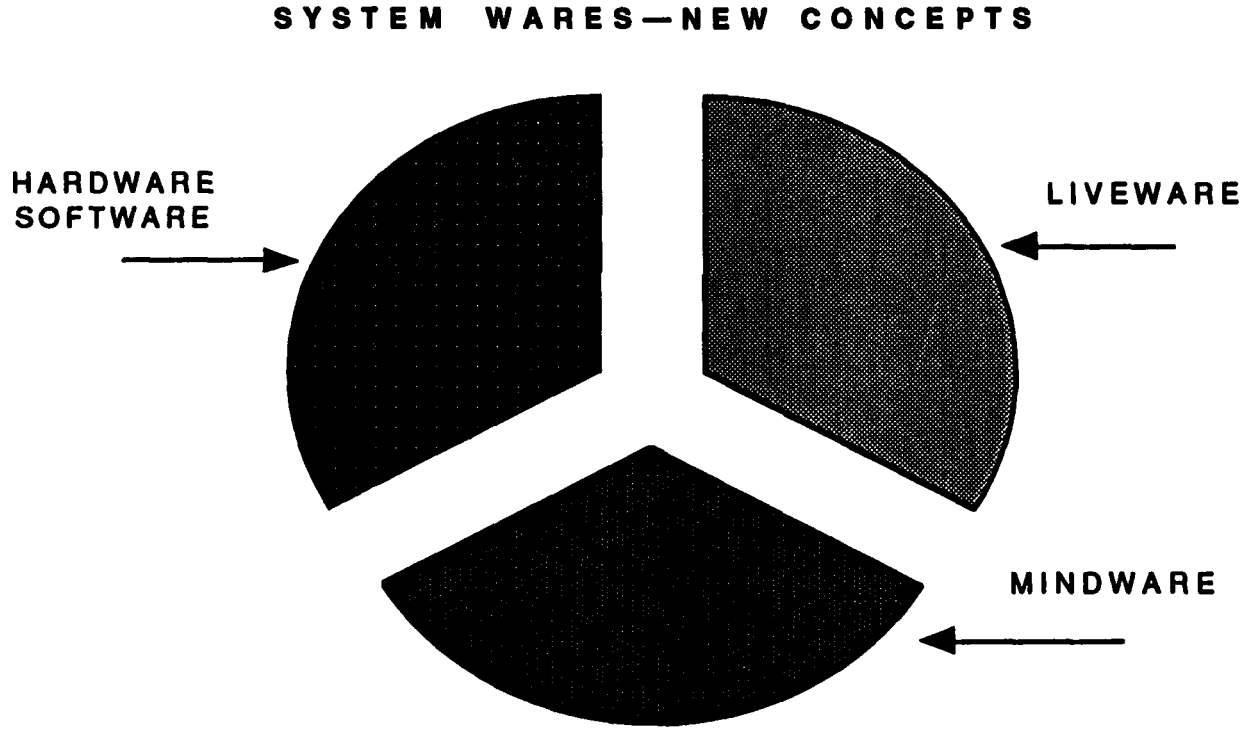
System — Concepts and "Wares"



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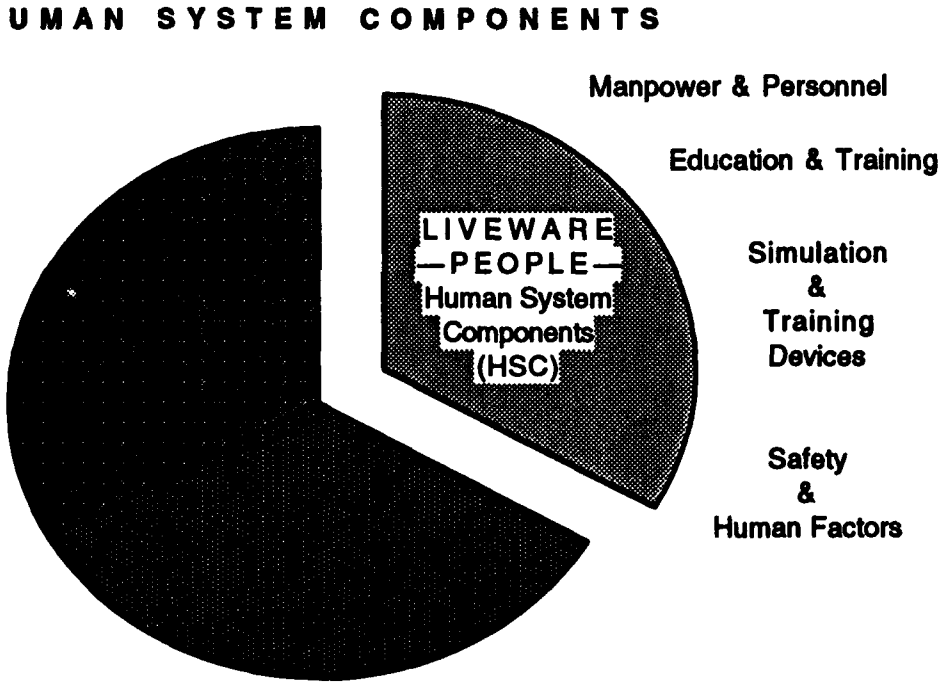
System — Concepts and "Wares"



Integrating HSC in System Design

- Integration of HSC in System Design
  - Tried by US Air Force during 1950's
  - With "Personnel Subsystem (PSS)" Approach
  - Manpower, Personnel, Training, and Human Factors Engineering
- Limited Success
  - Enabling Technologies Were Weak
  - Too Often Judged "Not Cost-Effective"
  - Dropped During 1960's

RSG.21

Mid-Century Engineering Design Drafting Bay

RSG.21

Human System Integration (HSI) — US Approaches

◊ The Problem(s):

- Acquisition Costs
- Life-Cycle Costs ($ & Manpower)
- Fielded-Equipment Inefficiencies

◊ The Solution(s):

- DoD Directive 5000.1, etc. (Incl. HSI or Liveware Integration)
- Service-Level Planning & Guidance
- Programs: MANPRINT, HARDMAN, IMPACTS — CALS/CE

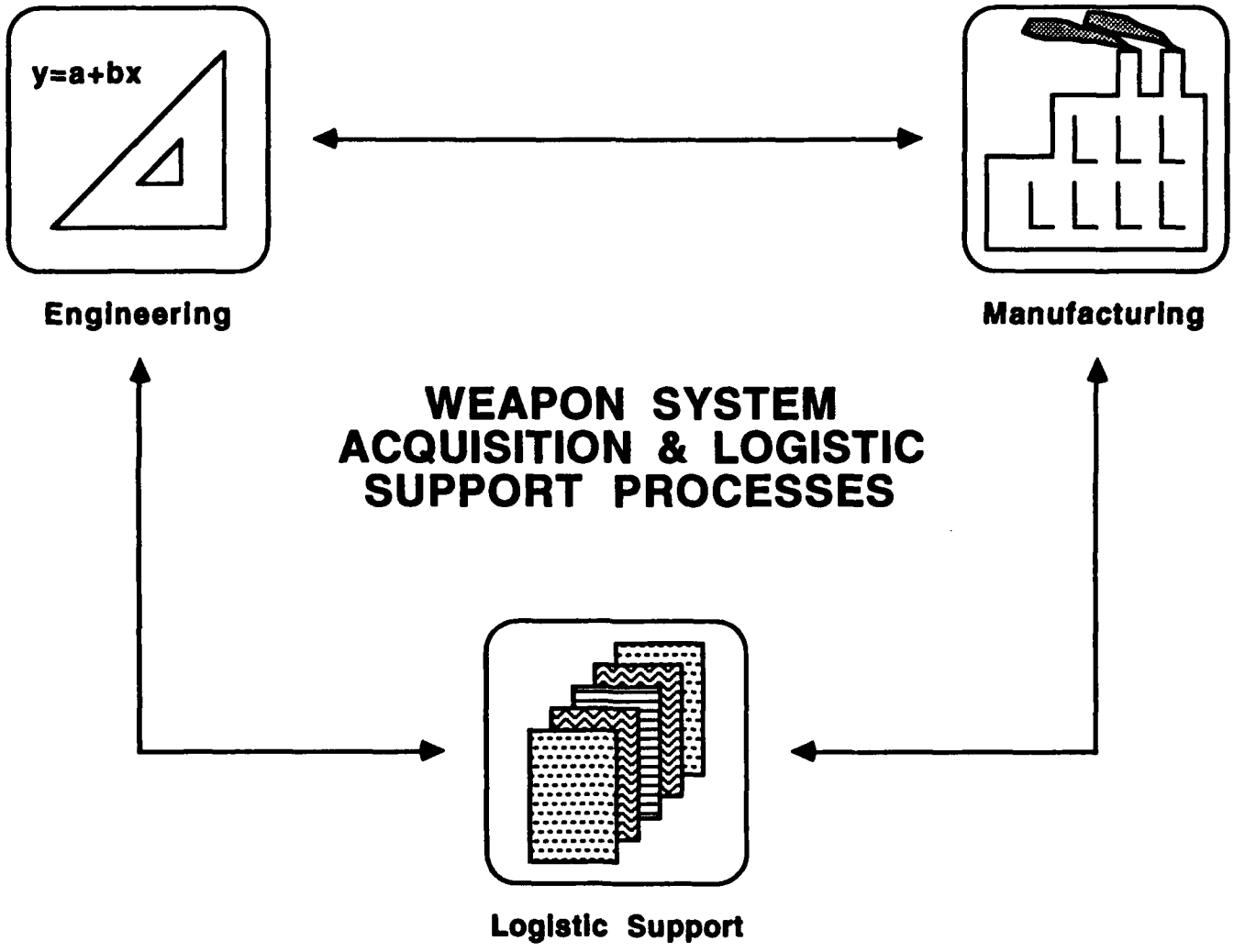
RSG.21

An Early CAD/CAM Work Station

11 Dec 92 (eaa)

SLIDE #10

CALS Integrated Environment



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Computer-Aided Acquisition and Logistic Support

- ◊ Goals
  - — Increase Operational Readiness and Industrial Competitiveness
- ◊ Objectives
  - — Reduce Lead Time
  - — Reduce Life-Cycle Costs
  - — Improve Weapon System Quality
- ◊ Process
  - — Evolve from Paper, Through
  - — Flat-File Digital Databases, To
  - — Integrated, Relational-Like, Digital Databases

Computer-Aided Acquisition and Logistic Support

Acquisition and Logistic Support Impact On, and Are Impacted By, Not Only Training, But Also All Human System Components (HSC)

Manpower & Personnel

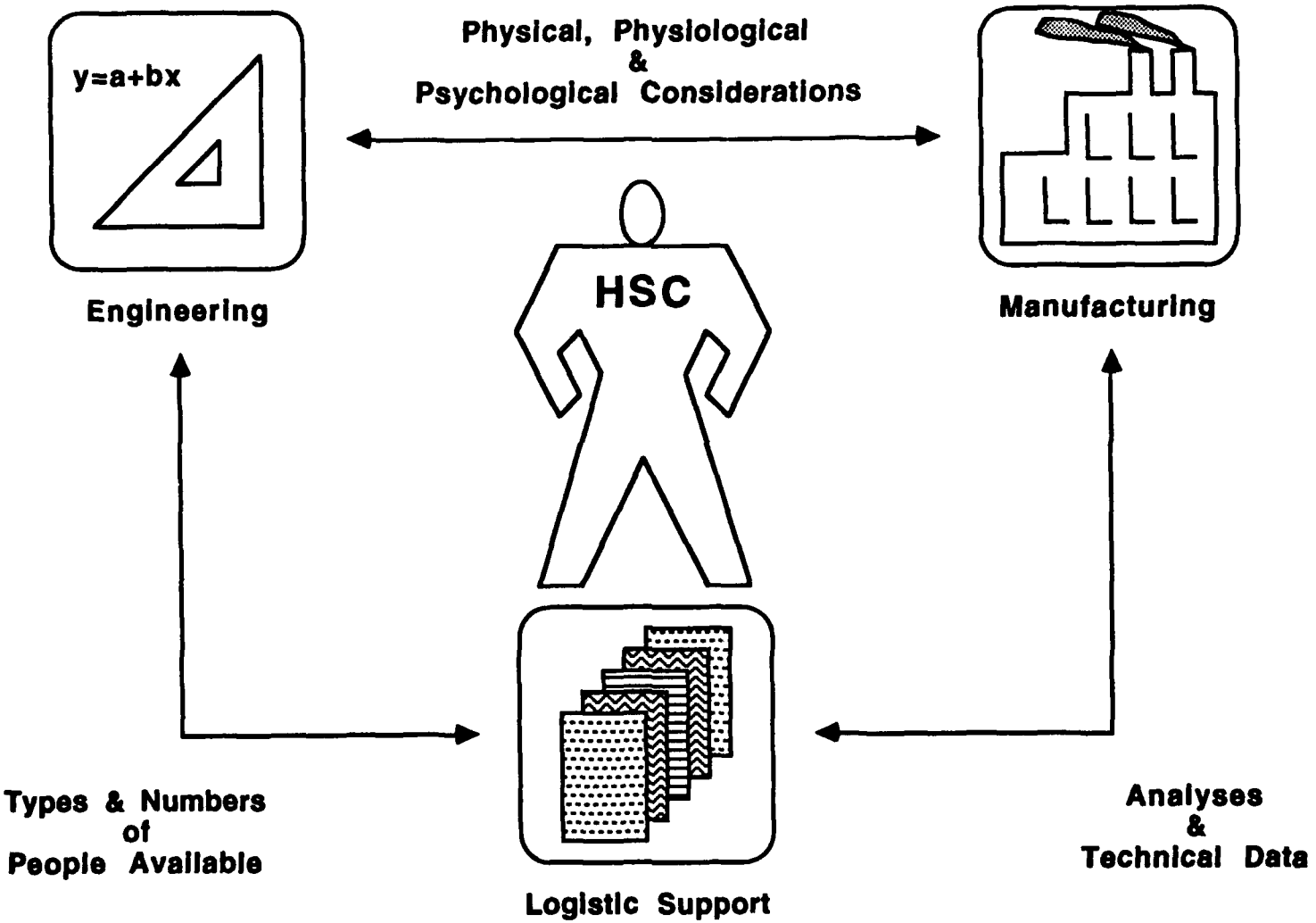
Education & Training

Simulation & Training Devices

Human Factors Engineering & Safety

1991 — CALS-HSC Formed to Integrate all HSC into CALS

Goal: Maximize CALS Objectives Through CALS-HSC Integration



CALS-HSC — 1992 Progress — HSI

- 30 Demonstrations of Software Tools at the HSI Software Fair, DoD Technical Group on Human Factors Meeting, 4 Nov 92, Huntsville AL
- CALS-HSC Data Element Dictionary — IDA Document D-1183 (October 1992)
- A Document* Based upon This Presentation on "Liveware Integration Needs" or More Broadly on Relations Among Liveware, HSI, & CALS-HSC — *IDA Document D-1087 (March 1993)

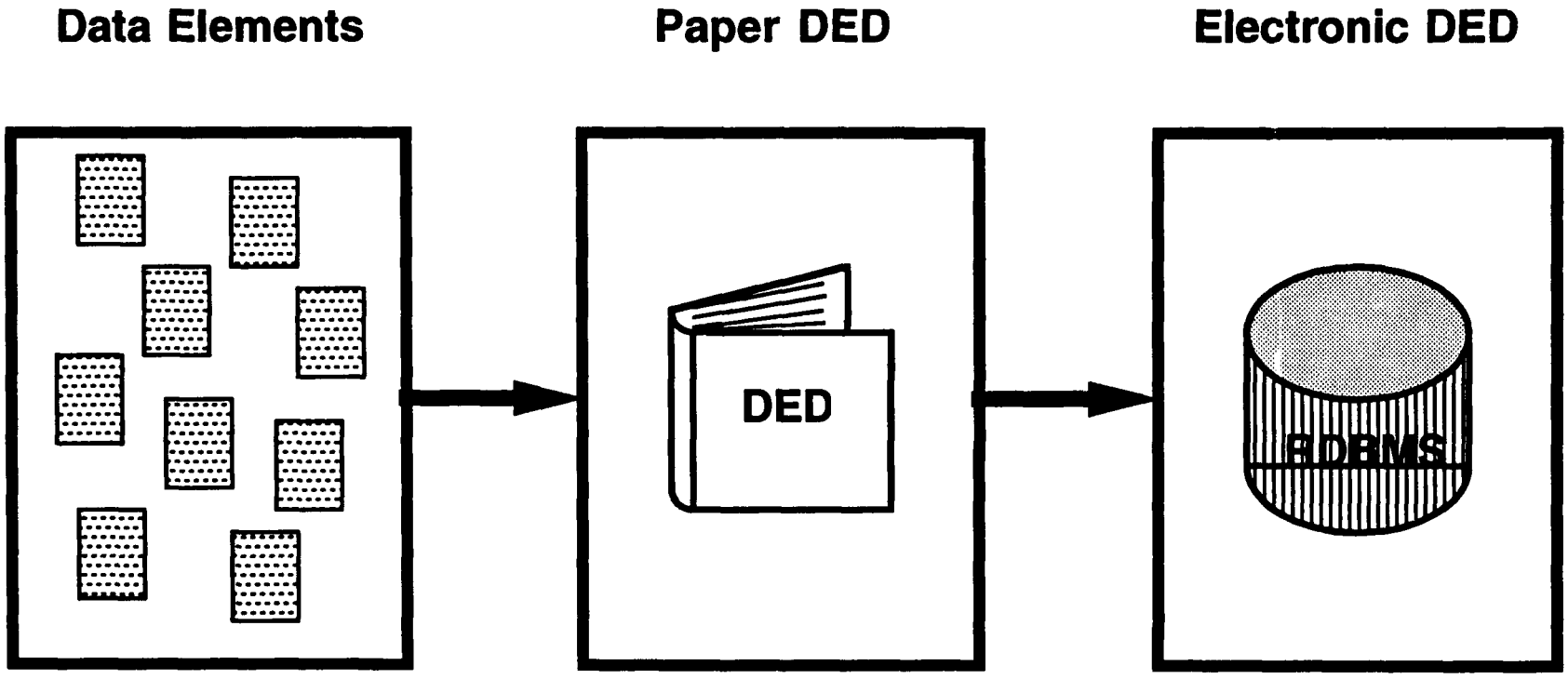
Demonstrations of HSI Software Tools

DoD-HFE-TG Meeting
(4 Nov 92, Huntsville AL)

- HSI Software Fair Sponsored by AFMC's Center for Supportability and Technology Insertion (CSTI/PIAT)
- Government-owned Microcomputer-based Software Tools Addressing Any HSI Elements
- Available Free-of-charge to All US Government Agencies
- Demonstrated by Government Representatives & Contractors

RSG.21

Data Element Dictionary (DED) — Process



RSG.21

CALS-HSC Data Element Dictionary

IDA Document D-1183 (October 1992)

- Incorporates Over 430 Data Elements
- Developed from Analyses of Standards and DIDs
- Complies with Relevant DoDDs, DoDIs, Handbooks, & Standards
- Interoperable with Logistic Support Analysis (LSA) Data Elements
- Coordinated with Industry & DoD CALS and HSC Communities

RSG.21

Needs for HSI Future Development

Briefing Documentation (IDA D-1087, March 1993)

To Include —

- Historical Roots of CALS-HSC Integration (HSI) Efforts
- Recent History of HSI-Related Activities and Efforts

To Relate —

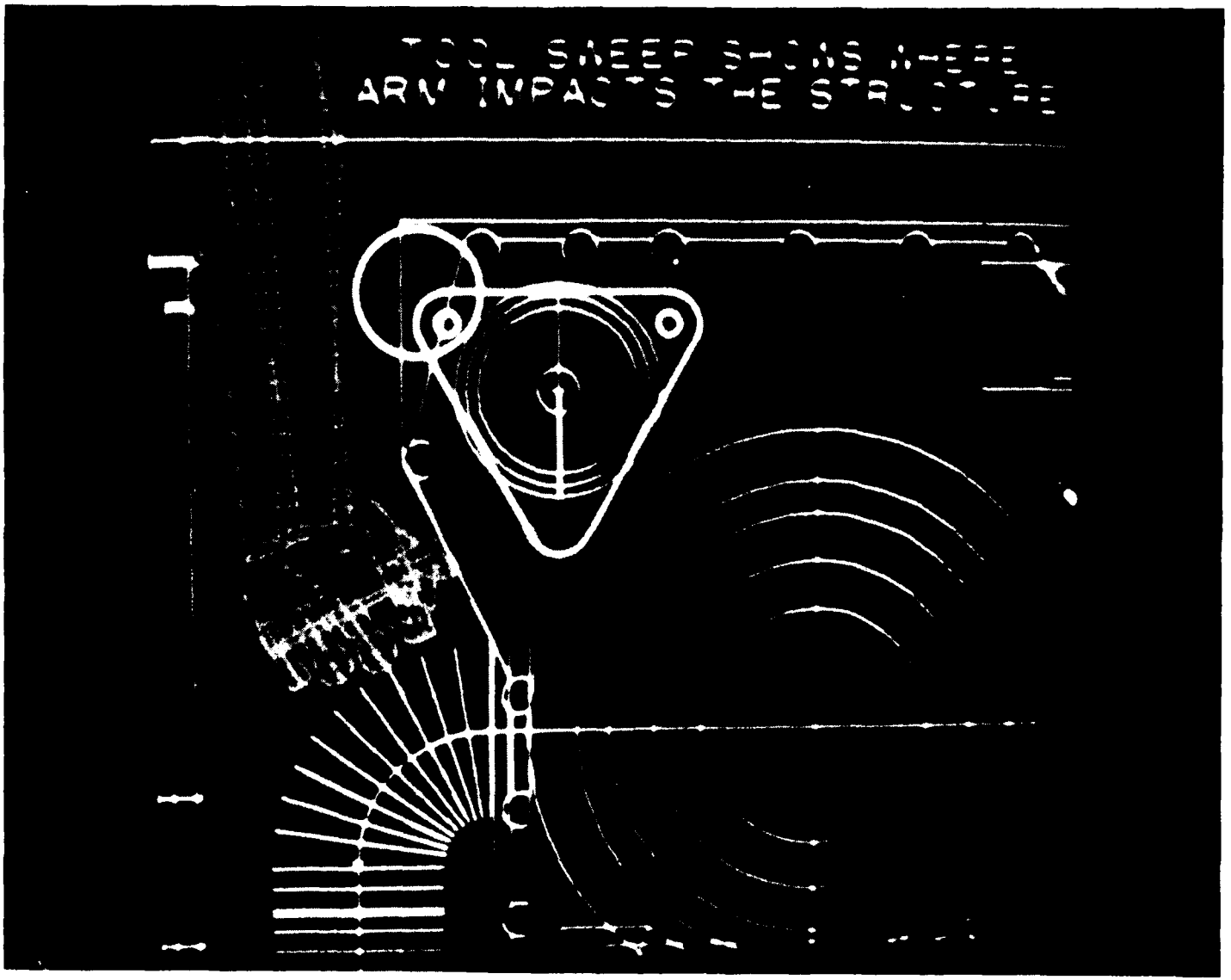
- Both Historical Roots and Recent HSI Activities
  To Dictionaries, Standards, and the CALS/CE Initiative

To Indicate —

- The Likely Future of Liveware, HSI, and CALS-HSC Efforts
  Are Consistent with CALS/CE Goals & Objectives

RSG.21

Computer-Generated Maintainability Test



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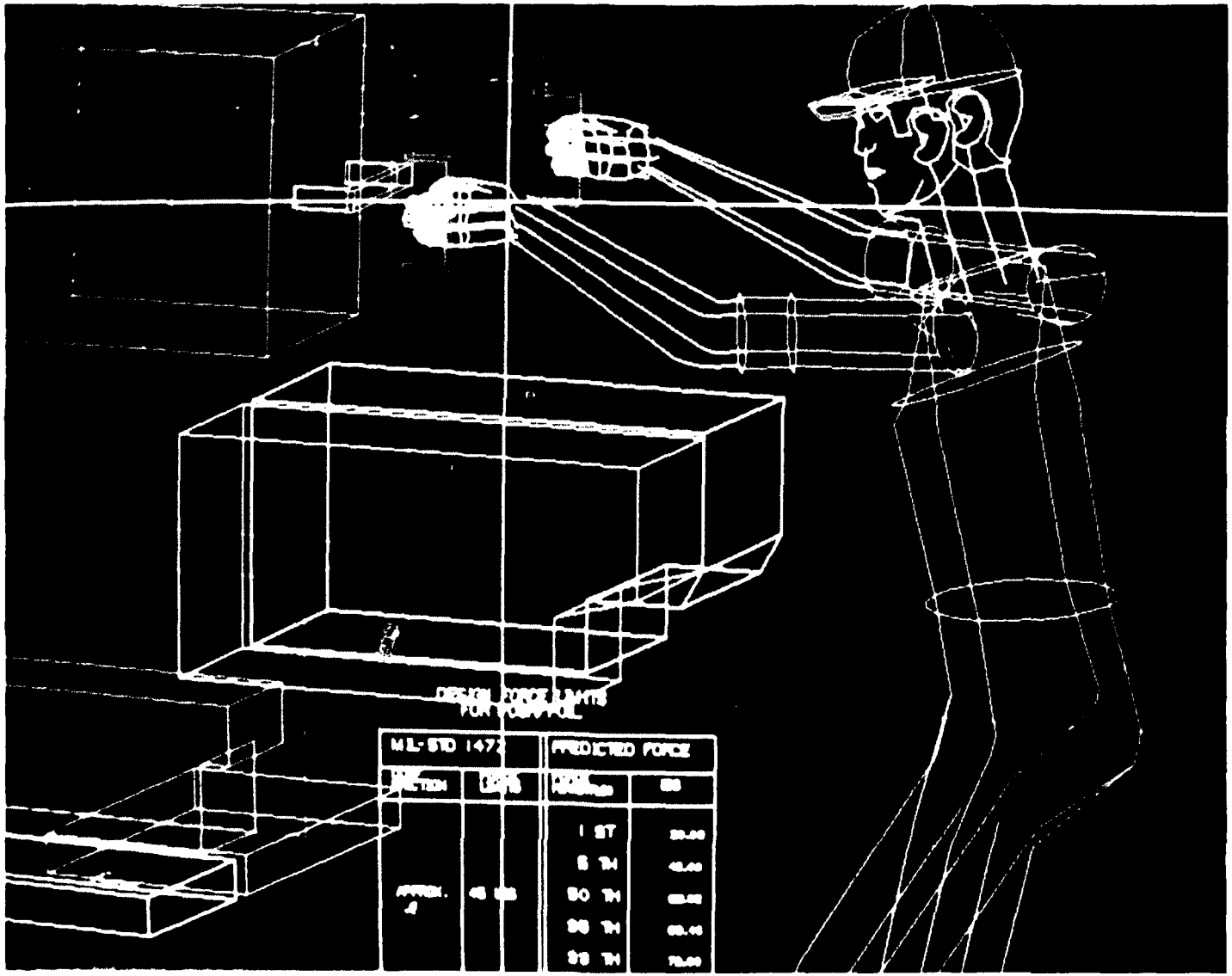
Computer-Generated Dynamic Manikin Model



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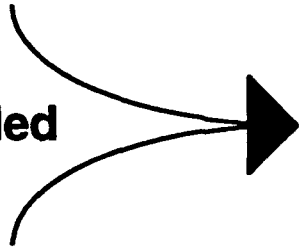
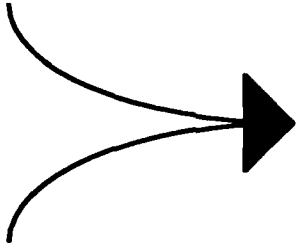
CALS-HSC Integration — Benefits

- Right the first time
- Data there when needed
- Already converted



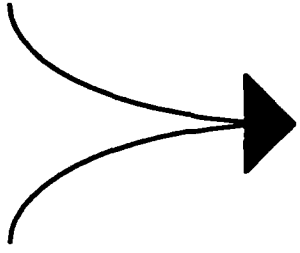
Reduced TIME

- Efficient databases
- Fewer retrofits/ECP's
- No duplication



Reduced COST

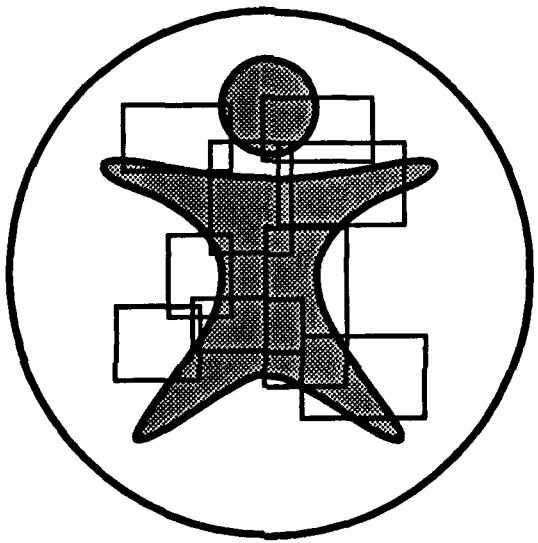
- Data consistency
- All factors considered
- Fewer design errors



Improved QUALITY

Computer-Aided Acquisition & Logistic Support —

Human System Components (CALS-HSC)



Human Systems Integration (HSI)

— "Liveware" Integration —

Will Be Achieved Through CALS-HSC